Target Developments in 2017

Jochen Ballof

on behalf of the target and ion source development group

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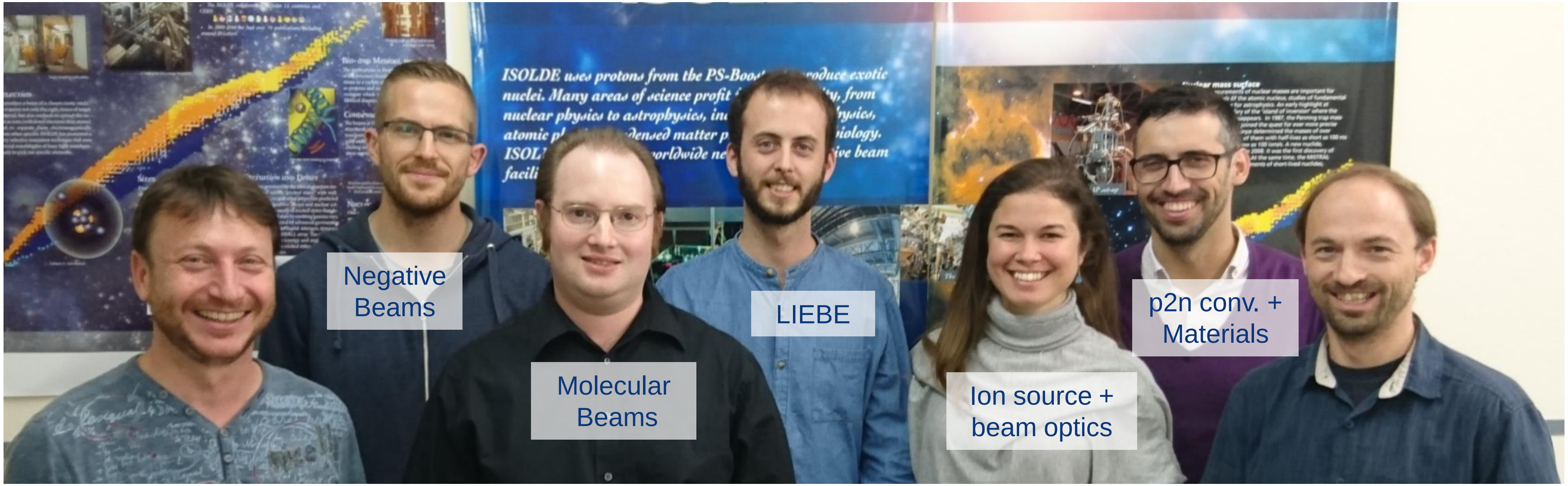
DEPARTMENT

The Target and ion Source Development (TISD) team



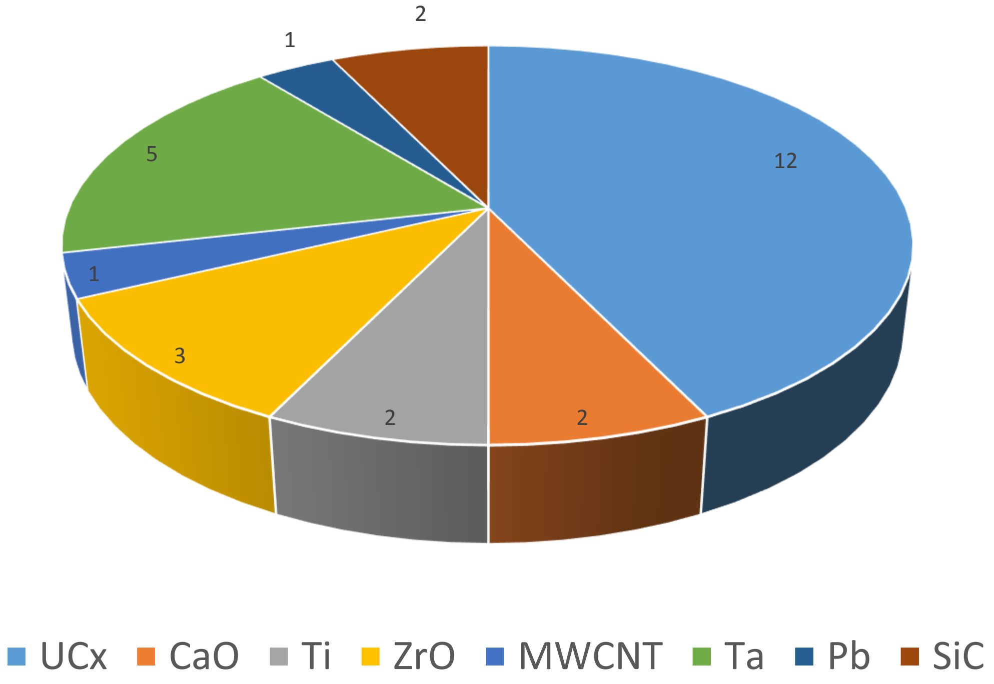
Thierry Stora
David Leimbach
Jochen Ballof
Ferran Boix Pamies
Yisel Martinez
Joao-Pedro Ramos
Sebastian Rothe

Providing a large choice of **intense** and **pure** radioactive beams

Constant development is required to keep ISOLDE at the forefront of RIB facilities

Target Operation in 2017

New Targets:



Month	Targets	Proton Scan + Yield Checks*	Operating Days **
April	3	3.34	38.9
May	6	2.07	51.4
June	4	3.50	54.3
July	4	1.55	54.7
August	4	1.16	54.0
September	5	2.18	56.4
October	5	3.34	55.7
November	5	2.07	57.0
Sum	**36**	**13.8 days**	**422.4 days**

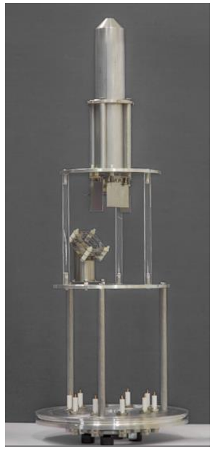
* lower estimate by DE60 position

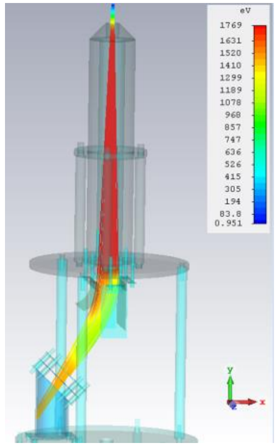
** line heating > 100 A

- 28 new target units for online operation produced
- 36 Targets scheduled

Dedicated test stand for ion source development

Details in Poster:
Negative beams





Main features:

- ion **beam extraction** and detection
- residual gas analyzer (RGA)
- **automated control and data recording (LabVIEW)**

First application:

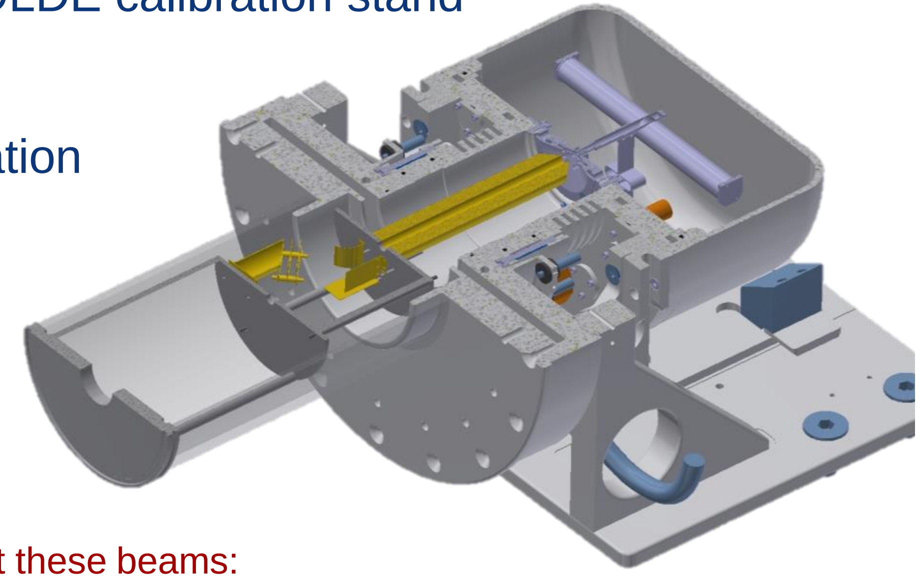
- **negative ion source** development
- investigation of source poisoning and regeneration

First measurements:

- electron evaporation as measure for the work function of new materials

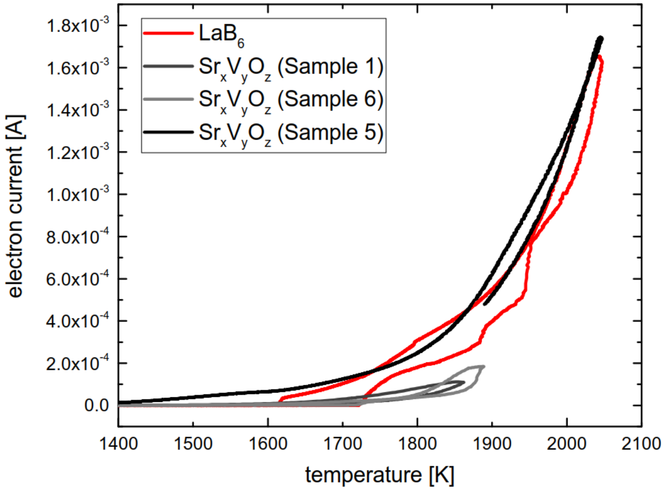
ISOLDE calibration stand

integration



Aiming at these beams:

F, Cl, Br, I, At, Po and as fluorides: W, Hf



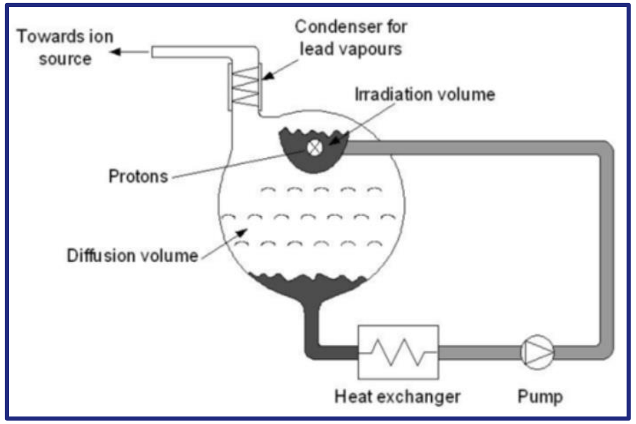
Future plans:

- long-term performance studies
- thermal stress tests
- destructive tests
  - **operational limits**
  - **failure mode analysis**

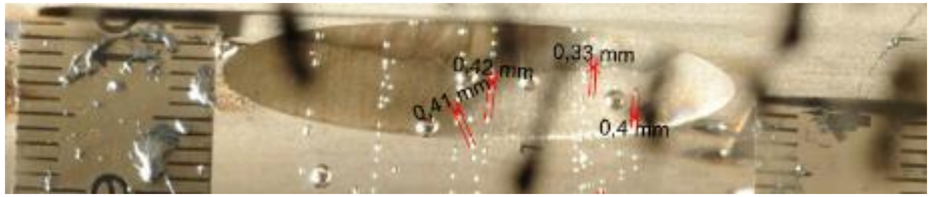
David Leimbach

The LIEBE project

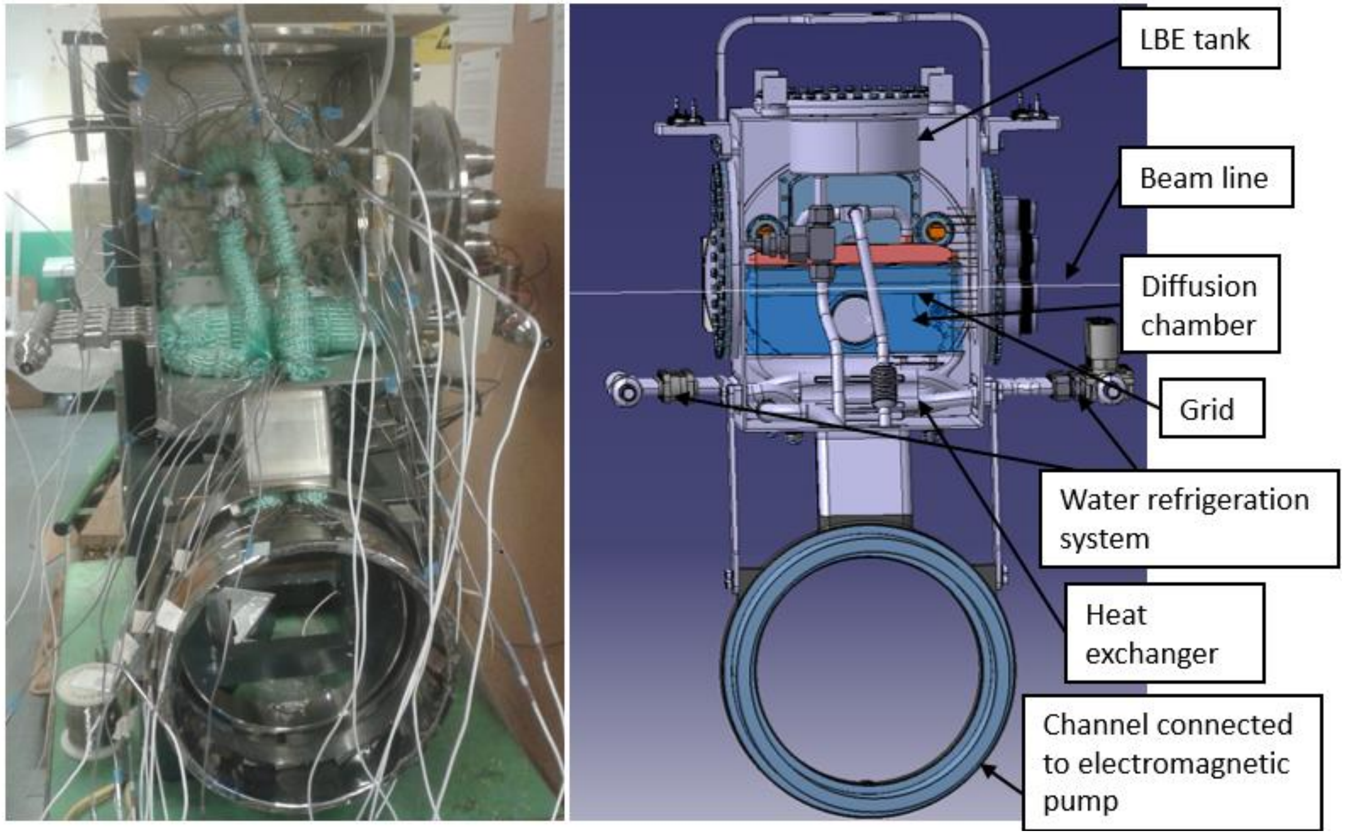
- Creating a shower by forcing a liquid Pb-Bi melt through a grid
- small drops -> short diffusion time
- high release efficiency for short lived species
- Ready for high-power beams (up to 4 MW)



Shower and droplets



Designed for: ^{177}**Hg**



LIEBE loop before enclosement.

Ferran Boix Pamies

The LIEBE target – Offline tests

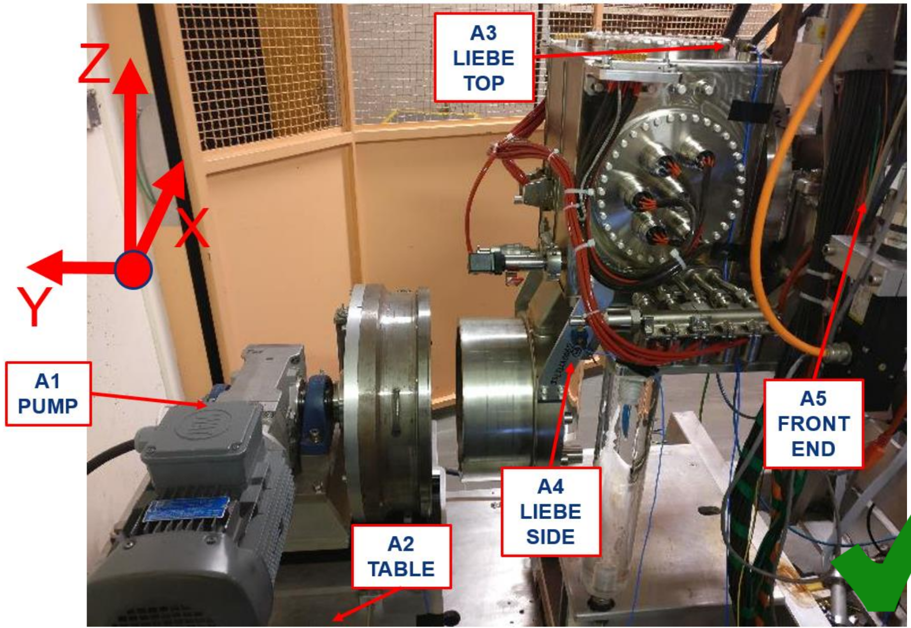
- Offline tests:
  - Leak tests
  - Vibration tests: Good stability of the pump and no direct transmission to the target

Vibration Severity Chart (mm/s)

	PUMP +X	PUMP +Y	PUMP +Z	LIEBE +X	LIEBE +Y	LIEBE +Z
Baseline	0.20	0.19	0.19	0.06	0.05	0.04
10Hz	0.83	0.54	0.47	0.52	0.17	0.22
20Hz	0.54	0.39	0.64	0.24	0.85	1.27
30Hz	0.88	0.79	1.13	0.45	0.39	0.19
40Hz	1.44	0.92	1.19	0.48	0.22	0.25
50Hz	4.28	1.76	1.41	0.73	0.27	[illegible]

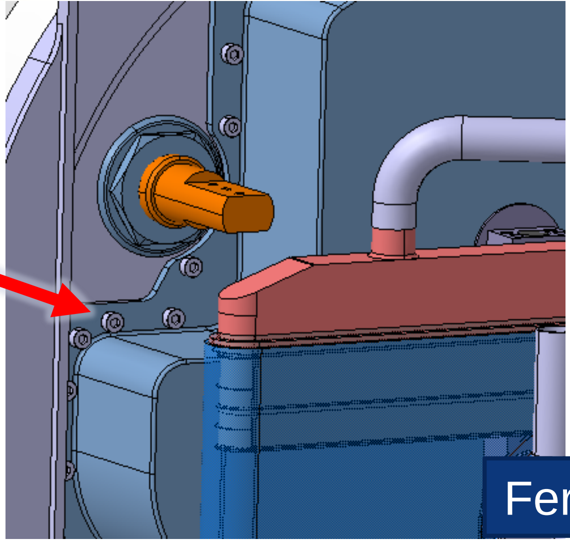
Standard model to evaluate the stability of the setup over time.

Vibration tests setup



LIEBE fully assembled and coupled to offline 1

Leak on vessel containing the ion source.



Ferran Boix Pamies

- Ion source tests:
  - Leak was found when heating the ion source to 1600 °C
  - LBE tests delayed until the leak is fixed
  - Manufacture of dedicated pieces to increase sealing pressure

Ion sources: Understanding and improving the VADIS source

Topic covered in Talks

Katerina Chrysalidis
RILIS Developments 2017

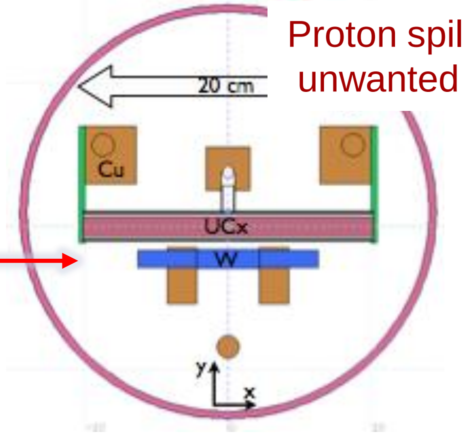
and

Yisel Martinez
Progress towards the commissioning of first stable beams at CERN-MEDICIS

Yisel Martinez and ISBM

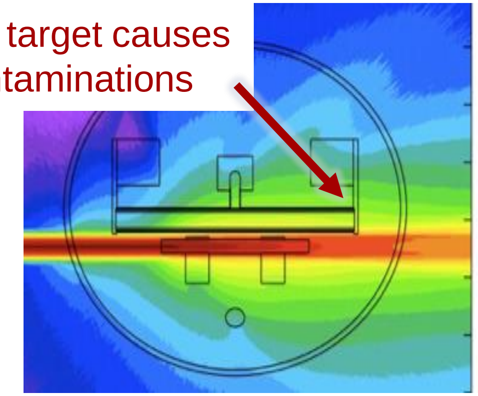
Proton to Neutron converter - Motivation

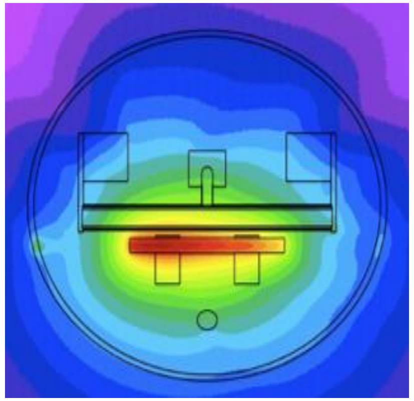
Current:



p beam

Proton spill on target causes unwanted contaminations

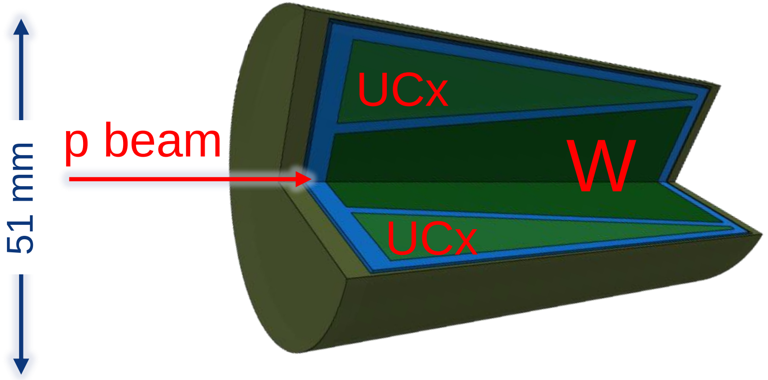




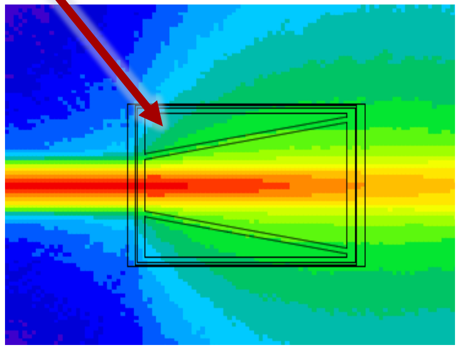
Proton fluence

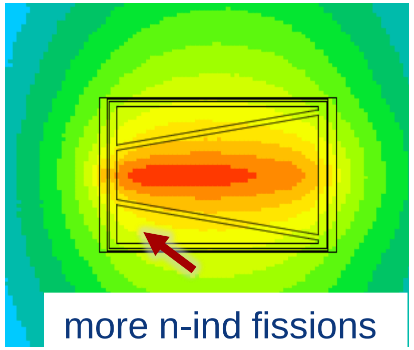
Neutron fluences

Improved:



reduced proton spill





more n-ind fissions

Preliminary time line

Apr-2017	Sep-2017	Jan->May-2018	?-2018	Aug->Dec-2018
Concept	Design + Offline Tests	Prototype ready	**ISOLDE test**	TRIUMF tests

Designed for: **pure beams** of **neutron rich isotopes**

	Improved	**Current**
n-ind fissions (/s)	2.79E**11**	4.55E**10**
p-ind fission ratio	10.8%	16.1%
Deposited Power	690 W	553 W
UCx Volume	60 cc	30 cc

➡ Higher yields for neutron induced fissions products

➡ Less isobaric contamination

Status:

Systematic FLUKA simulations for geometry optimizations done

Thermomechanical simulations ongoing

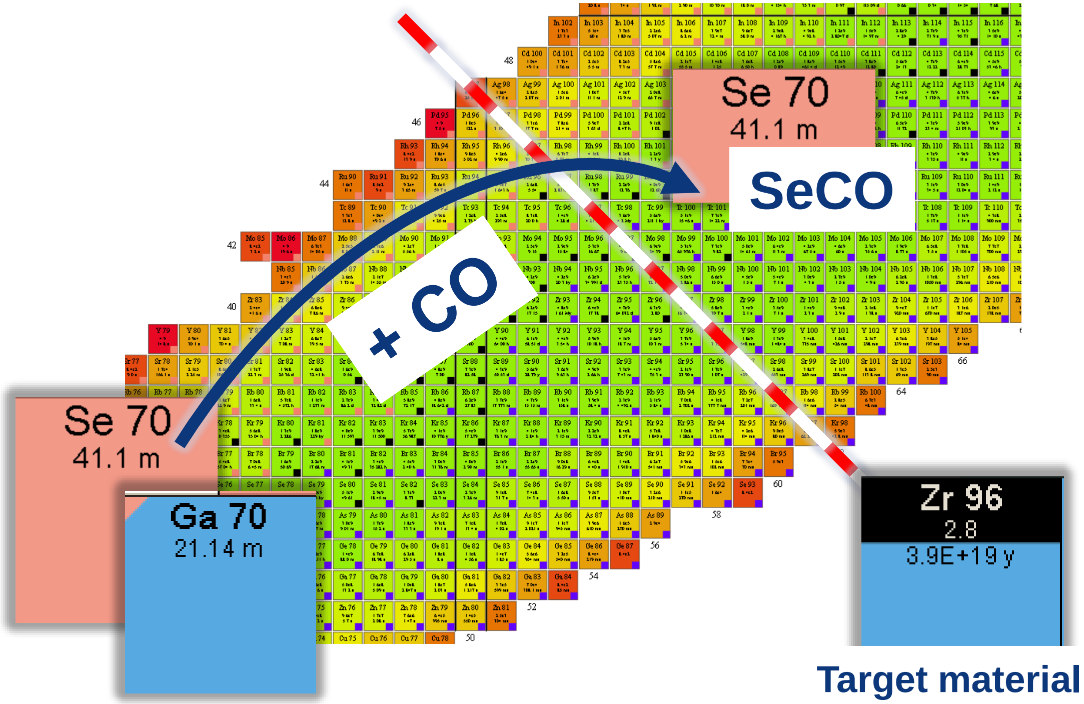
More about thermo-mechanics:

Talk Yisel Martinez,

MEDICIS beams

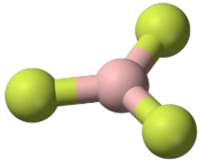
João Pedro RAMOS

Molecular Beams – Why?



- **Beam purification**
  - Shift the mass region to a higher mass to avoid isobaric contaminants. e.g. GeS, SnS, SeCO, LnO
- **Beam extraction by *In-situ* volatilization**
  - Elements with very low volatility are not released
  - Reactive elements can be chemically trapped

$$^{8}B \xrightarrow{SF_6\,(g)} {}^{8}BF_3$$

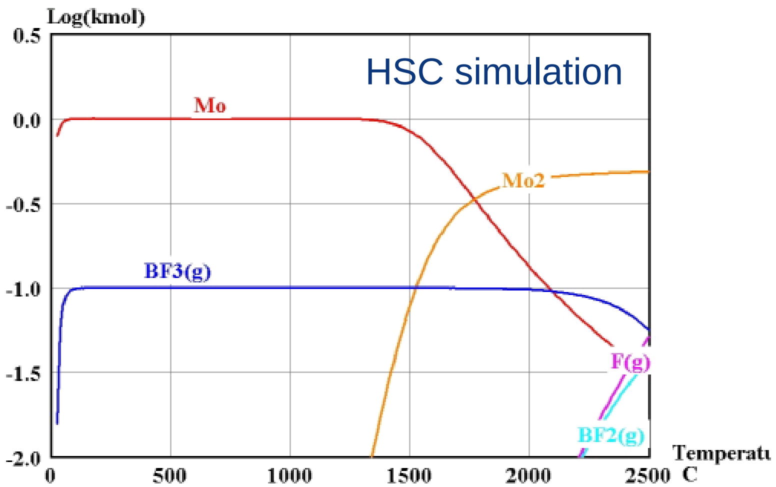


Boron

Low Volatility (m.p. 2076 °C)
reactive with many metals

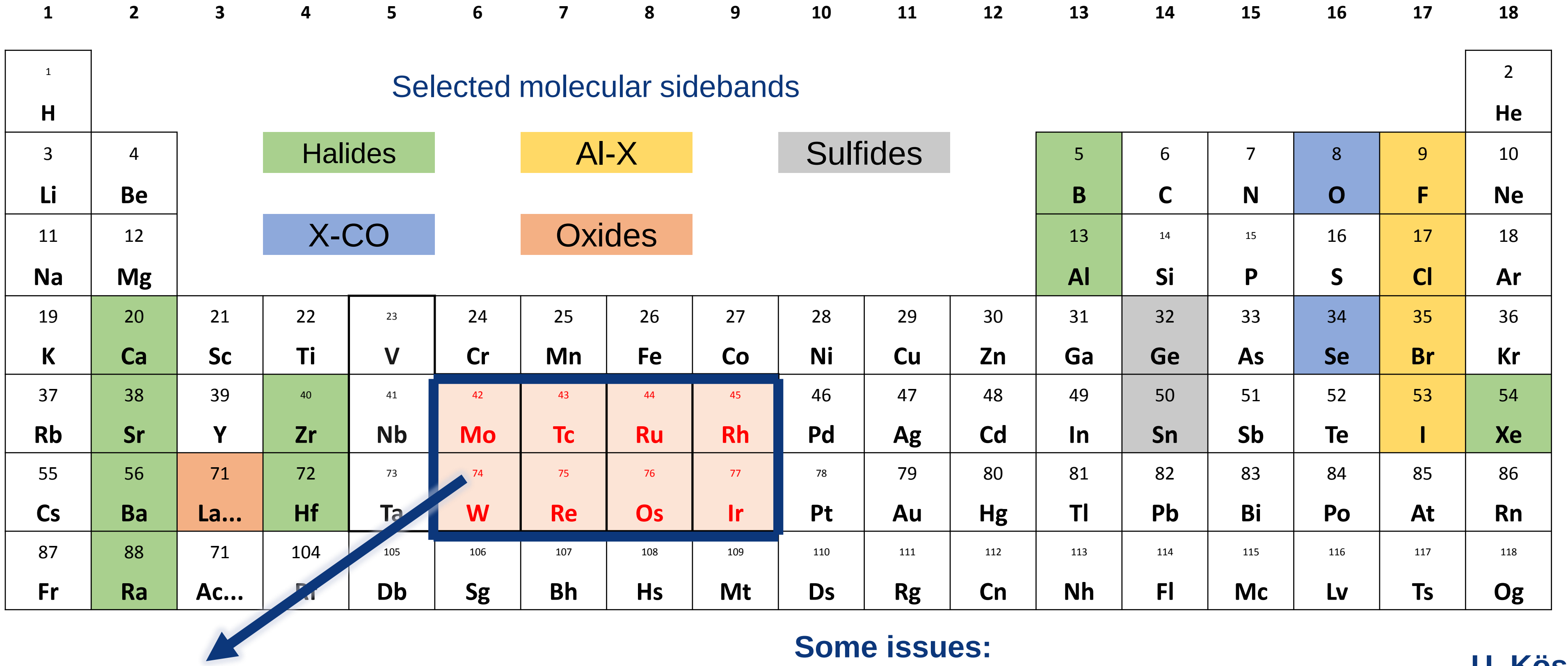
Boron trifluoride

gaseous even at RT
very stable



Molecular Beams – The classical approach

Formation of molecules under low pressure conditions and high temperatures



Selected molecular sidebands

🟩 Halides
🟨 Al-X
⬜ Sulfides
🟦 X-CO
🟧 Oxides

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H																	2 He
3 Li	4 Be											🟩 5 B	6 C	7 N	🟦 8 O	🟨 9 F	10 Ne
11 Na	12 Mg											🟩 13 Al	14 Si	15 P	16 S	🟨 17 Cl	18 Ar
19 K	🟩 20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	⬜ 32 Ge	33 As	🟦 34 Se	🟨 35 Br	36 Kr
37 Rb	🟩 38 Sr	39 Y	🟩 40 Zr	41 Nb	🟧 42 Mo	🟧 43 Tc	🟧 44 Ru	🟧 45 Rh	46 Pd	47 Ag	48 Cd	49 In	⬜ 50 Sn	51 Sb	52 Te	🟨 53 I	🟩 54 Xe
55 Cs	🟩 56 Ba	🟧 71 La...	🟩 72 Hf	73 Ta	🟧 74 W	🟧 75 Re	🟧 76 Os	🟧 77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	🟩 88 Ra	71 Ac...	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og

Refractory metals are expected to form oxide sidebands

Some issues:

- Oxygen corrosive to VADIS
- Decomposition on Ta surfaces
- Fast sintering of UO_2 / ThO_2 targets
- Elevated temperatures for some elements necessary

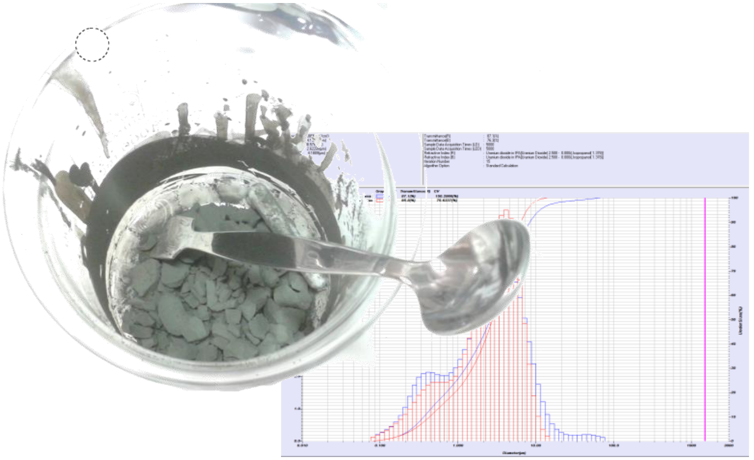
U. Köster et al.
NIMB 266 (2008), 4229
EPJ-ST (2007), 285

Prototype #630

Tested on GPS last week

New target material:

UO_2 + MgO



Idea:

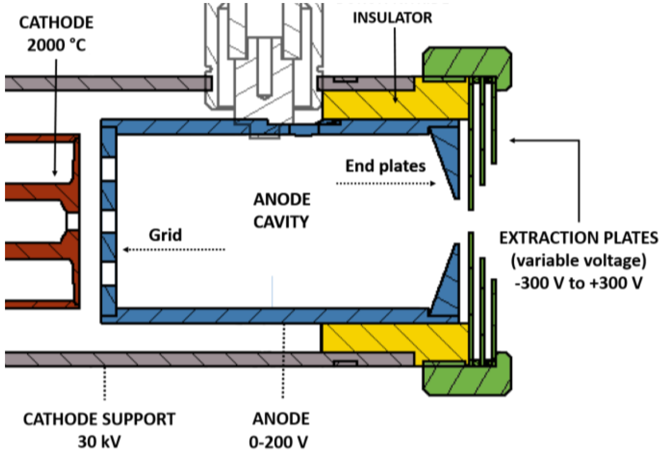
- Prevent sintering of UO_2 by adding MgO
- Extract refractory Oxides

Aiming at these beams:

Mo, Tc, Ru, Rh, W, Re, Os, Ir

New ion source:

VADIS with tunable extraction plate



Increased laser ionization efficiency

Preliminary results:

- New source is reliable and provides high efficiencies
- Target material usable till about 1300 °C
- High Mg Currents at higher temperatures

Analysis of data ongoing

Thanks to **ISOLTRAP** and **IDS** for their support!

Frank Wienholtz
Maxime Mougeot
Dinko Atanasov
Vladimir Manea

Christophe Sotty
James Cubiss
Andrei Andreyev
…

Thanks to **RILIS** for 3 elements in 3 days!

Katerina Chrysalidis
Shane Wilkins

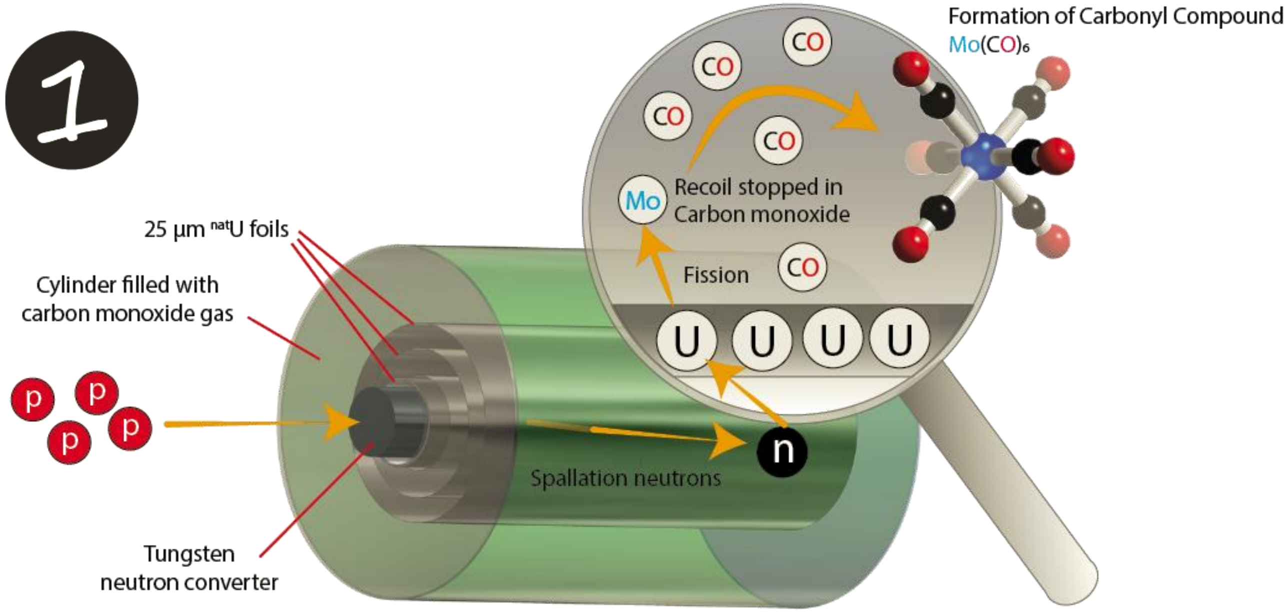
Bruce Marsh
Camilo Buitrago

Thanks to **RP** for the availability and support on very short notice!

Alexandre Dorsival
Matthieu Deschamps

Molecular Beams – A new approach

- Avoid slow diffusion in solids and use fission recoil effect instead
- Thermalize recoils in carbon monoxide atmosphere
- Volatile metal carbonyl compounds form readily at RT

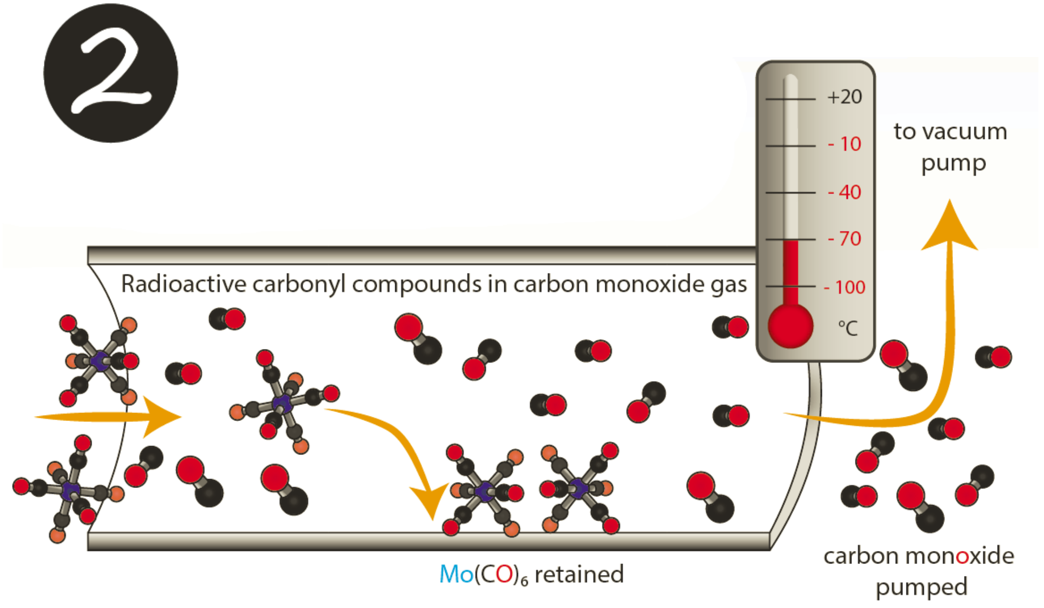


- FLUKA + SRIM: ~ 10^7 /µC ^{105}Mo stopped in gas

Aiming at these beams:

Mo, Tc, Ru, Rh, W, Re, Os, Ir

- Retain Carbonyl compound on cold surface
- Pump the excess carbon monoxide gas

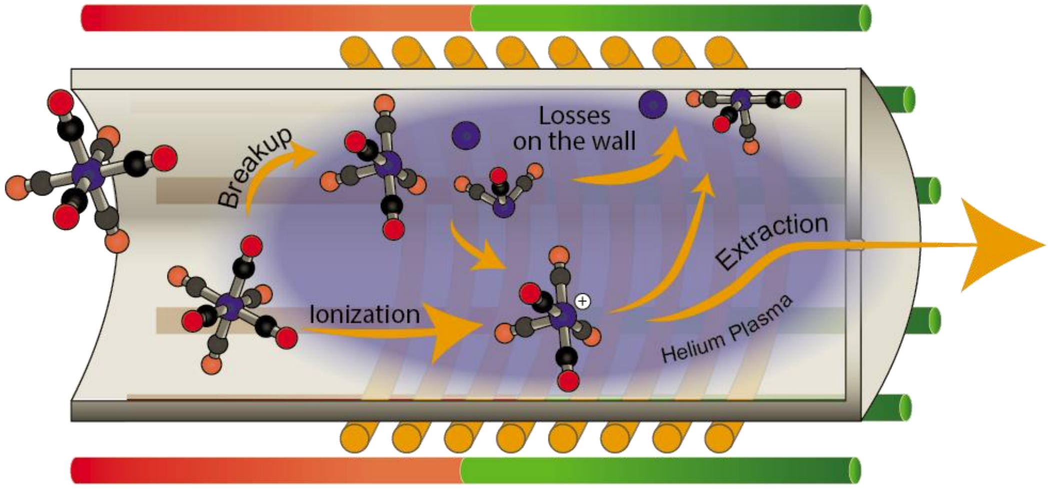


- Monte-Carlo-Simulation: temperatures around – 70 °C necessary for quartz surfaces

Christoph Seiffert

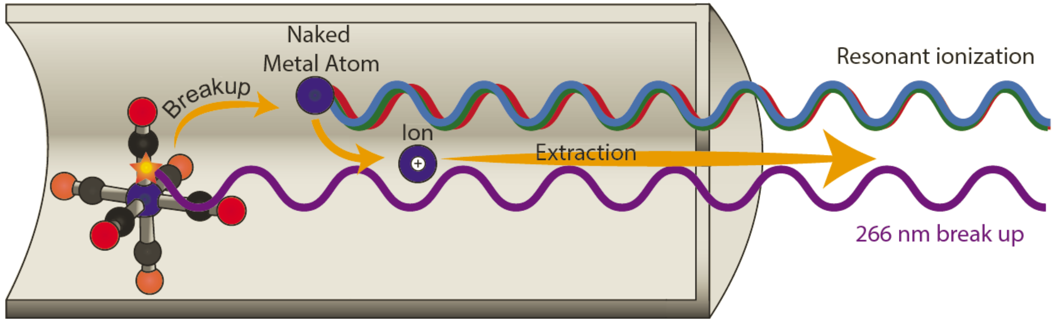
Molecular Beams – A new approach

③ Ionization of the molecule with plasma or electron impact sources:

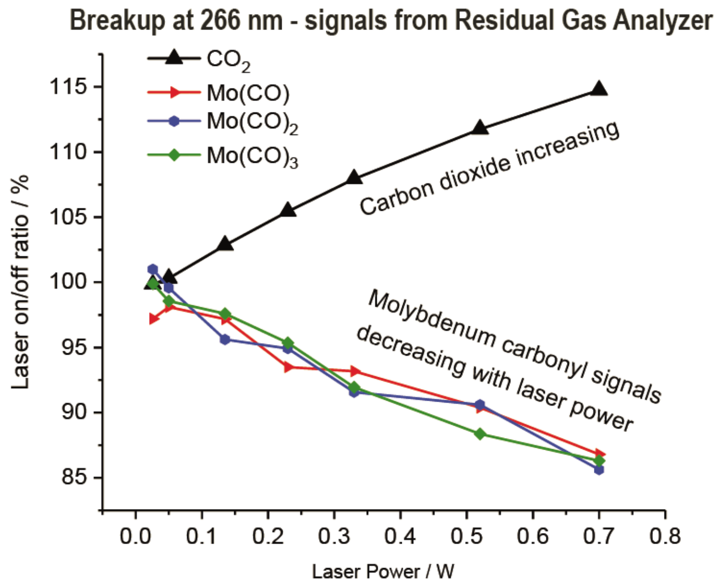


- Systematic tests with VADIS, COMIC and HELICON sources -> Efficiencies not yet sufficient
- Up next: ECR source

Alternatively:
Laser breakup followed by ionization:



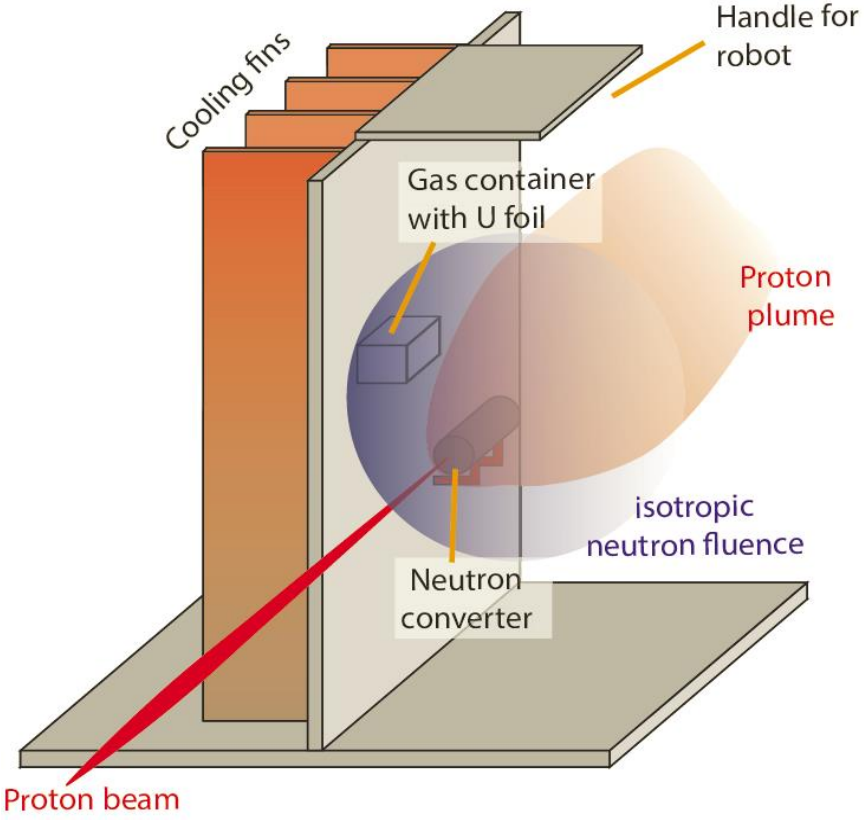
- Ideal test-case for laser breakup: low FBDE
- Breakup of $Mo(CO)_6$ vapors tested:



Molecular Beams – A new approach

Carbonyl compounds are fragile, do they survive at ISOLDE?

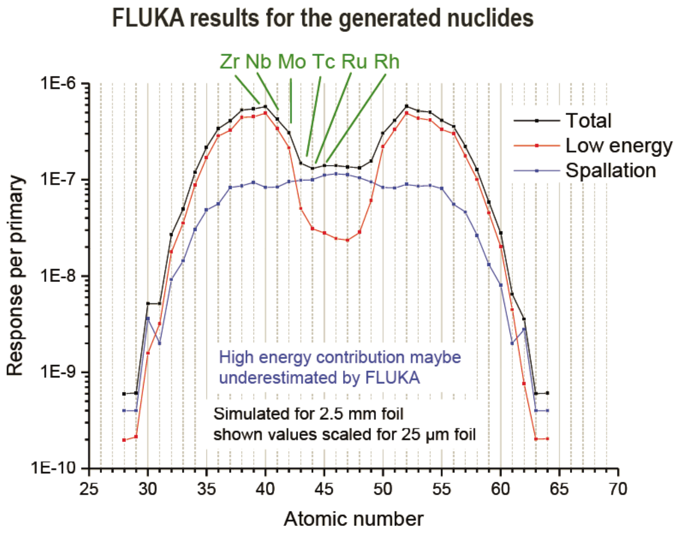
Irradiation experiment



Planned for 2018

Pump gas container over charcoal trap

Gamma Spectroscopy



high production cross sections of transition metals in uranium foils

Goals:

- Validate production and stopping simulations
- Carbonyl formation + survival
- Surface interactions

Done:

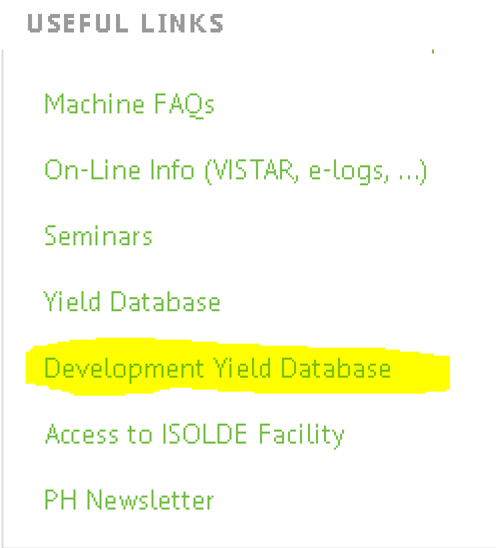
- Radioactive Inventory simulated
- Heat transfer calculation

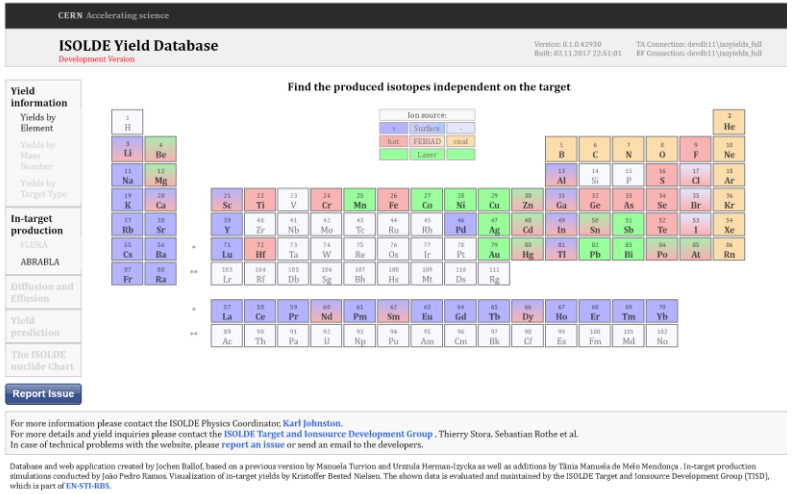
To do:

- RP-Simulations
- Mechanical design

ISOLDE Yield Database

http://cern.ch/isolde



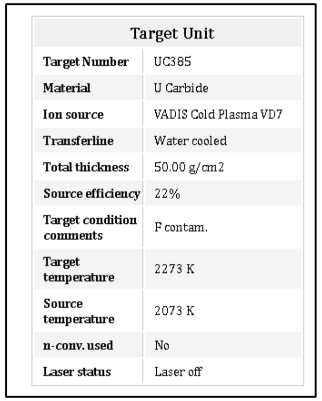


ISOLDE Yield Database
Development Version

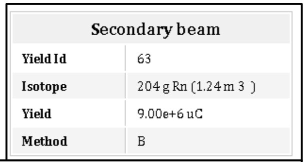
Find the produced isotopes independent on the target

For more information please contact the ISOLDE Physics Coordinator, Karl Johnston.
For more details and yield inquiries please contact the ISOLDE Target and Ionsource Development Group , Thierry Stora, Sebastian Rothe et al.
In case of technical problems with the website, please report an issue or send an email to the developers.

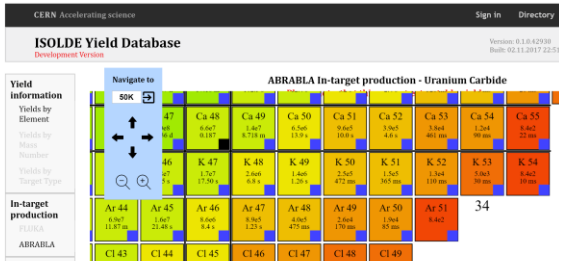
Database and web application created by Jochen Ballof, based on a previous version by Manuela Turrion and Urszula Herman-Izycka as well as additions by Tânia Manuela de Melo Mendonça . In-target production simulations conducted by João Pedro Ramos. Visualization of in-target yields by Kristoffer Bested Nielsen. The shown data is evaluated and maintained by the ISOLDE Target and Ionsource Development Group (TISD), which is part of EN-STI-RBS.



Target Unit	
Target Number	UC385
Material	U Carbide
Ion source	VADIS Cold Plasma VD7
Transferline	Water cooled
Total thickness	50.00 g/cm2
Source efficiency	22%
Target condition comments	F contam.
Target temperature	2273 K
Source temperature	2073 K
n-conv. used	No
Laser status	Laser off



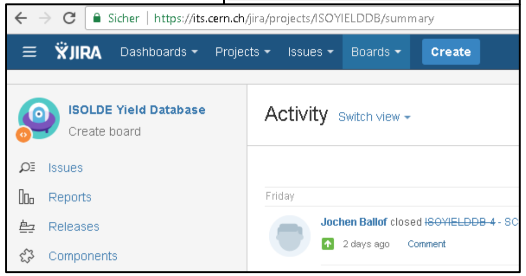
Secondary beam	
Yield Id	63
Isotope	204 g Rn (1.24 m 3)
Yield	9.00e+6 uC
Method	B



ISOLDE Yield Database
Development Version

ABRABLA In-target production - Uranium Carbide

47	Ca 48 6.6e7 0.187	Ca 49 1.4e7 8.718 m	Ca 50 6.5e6 13.9 s	Ca 51 9.6e5 10.0 s	Ca 52 3.9e5 4.6 s	Ca 53 3.8e4 461 ms	Ca 54 1.2e4 90 ms	Ca 55 8.4e2 22 ms	
46	K 47 1.7e7 17.50 s	K 48 2.6e6 6.8 s	K 49 1.4e6 1.26 s	K 50 2.5e5 472 ms	K 51 1.5e5 365 ms	K 52 1.3e4 110 ms	K 53 5.0e3 30 ms	K 54 8.4e2 10 ms	
Ar 44 6.9e7 11.87 m	Ar 45 1.6e7 21.48 s	Ar 46 8.6e6 8.4 s	Ar 47 8.9e5 1.23 s	Ar 48 4.0e5 475 ms	Ar 49 2.6e4 170 ms	Ar 50 1.9e4 85 ms	Ar 51 8.4e2	34	
Cl 43	Cl 44	Cl 45	Cl 46	Cl 47	Cl 48	Cl 49			

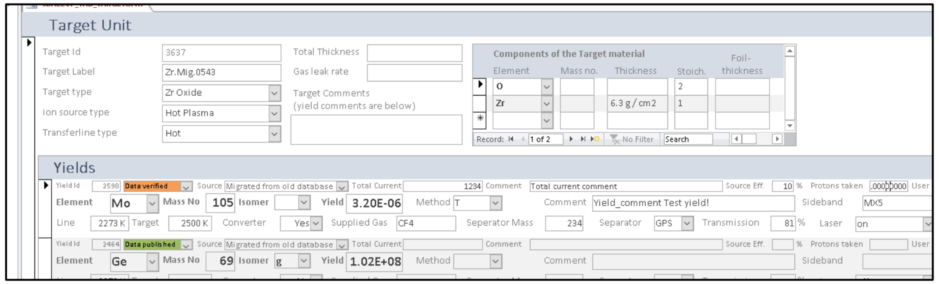


ISOLDE Yield Database

Activity

Friday

Jochen Ballof closed ~~ISOYIELDDB-4~~ - SC
2 days ago



Target Unit

Target Id	3637	Total Thickness	
Target Label	Zr.Mig.0543	Gas leak rate	
Target type	Zr Oxide	Target Comments (yield comments are below)	
ion source type	Hot Plasma		
Transferline type	Hot		

Components of the Target material

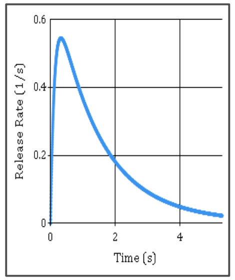
Element	Mass no.	Thickness	Stoich.	Foil-thickness
O			2	
Zr		6.3 g / cm2	1	

Record: 1 of 2 No Filter Search

Yields

Yield Id 2598 Data verified Source Migrated from old database Total Current 1234 Comment Total current comment Source Eff. 10 % Protons taken .000000 User
Element Mo Mass No 105 Isomer Yield 3.20E-06 Method T Comment Yield_comment Test yield! Sideband MX5
Line 2273 K Target 2500 K Converter Yes Supplied Gas CF4 Seperator Mass 234 Separator GPS Transmission 81 % Laser on

Yield Id 2464 Data published Source Migrated from old database Total Current Comment Source Eff. % Protons taken User
Element Ge Mass No 69 Isomer g Yield 1.02E+08 Method Comment Sideband



Features

- CERN SSO
- New Database design
- In target production (ABRABLA)
- Release curves available
- More target details visible
- Issue tracking

Philosophy

- All measurements (TISD, USERS) get entered
- Manually change attribute (measured -> validated -> published)
- Attribute determines visibility (after login, no login required)

Future

- Web based interface allows entering of yields to registered users
- Add FLUKA results for in-target production
- Add yield prediction
- Establish link to CRIBE database

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Thanks to the TISD and RILIS teams

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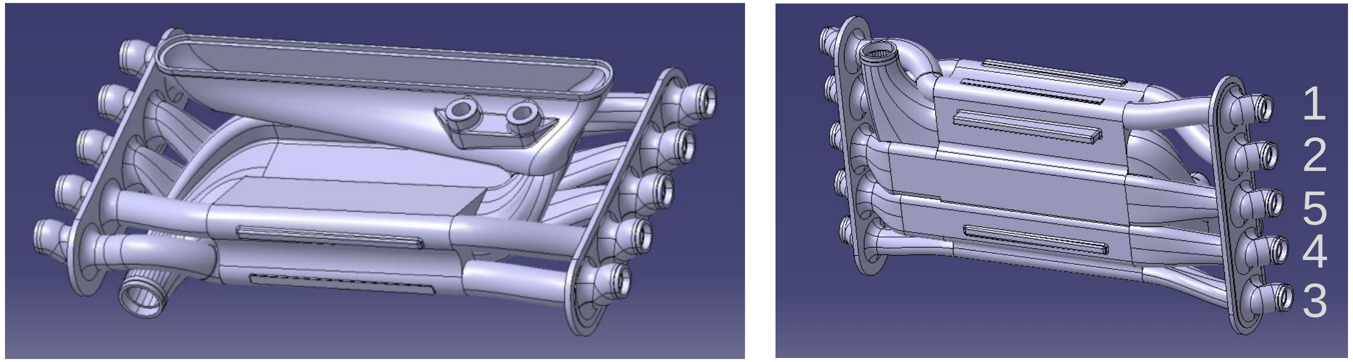
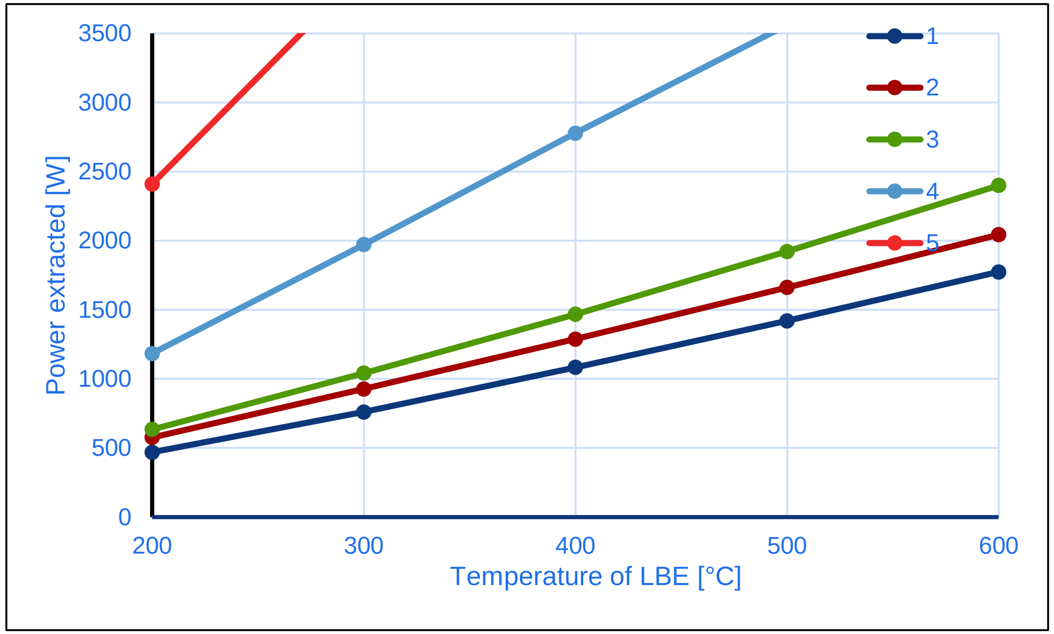
The LIEBE target – Offline tests

- Pending offline tests:
  - Melt of LBE
  - Level sensor tests
  - Heat exchanger calibration



3D model of the heat exchanger, 5 water channels to cope with 5 different temperatures.



Ansys CFX simulations of heat exchanged for every water channel.

- Offline tests with LBE delayed to January
- Test of LIEBE Online intervention procedure during 2018 shutdown
- Operational review April
- Target to be installed at GPS end of October 2018

Ferran Boix Pamies

Neutron deficient SeCO beams

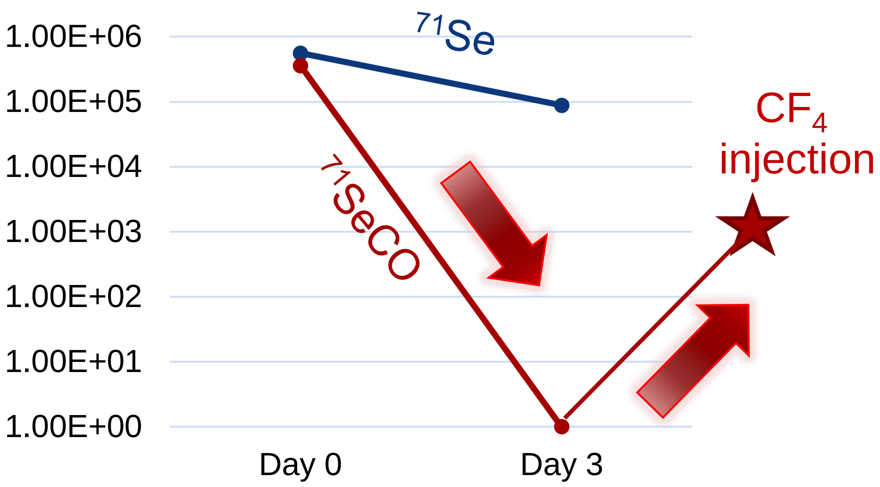
Target #605 and #612
Zirconia fibers, stabilized with ca. 10% Yttria

Principle: Se + CO → SeCO

Shifting the mass to get pure beams

Beam available since many years.

but….

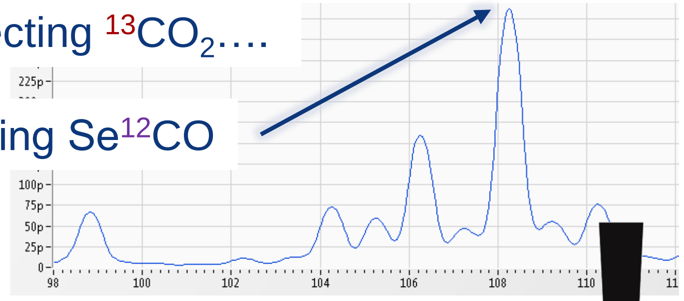


- SeCO gone after a few days
- Atomic Se still released after days

Why does SeCO disappear, even if we inject CO_2?

Injecting $^{13}CO_2$….

…extracting Se^{12}CO



Injected CO_2 gas does not promote SeCO formation!

What's the source of carbon?

Carbon from the ion source?

-> Placed graphite grid, but still depleting

Carbon from the target material?

-> EDS (preliminary) shows no carbon in ZrO fibers

Indications, that CF_4 gas might serve as carbon source. Work in progress.

Boron fluoride beams

Principle: $B + 3\,F \rightarrow BF_3$ *Volatilization of refractory boron by injection of SF_6 gas*

First prototype #499

- Small gas leak (3.7e-5 mbar L / s)
- Absence of TaF_x and SF_x in mass spectra

→ Unit did not produce BFx beams
no fluorine saturation

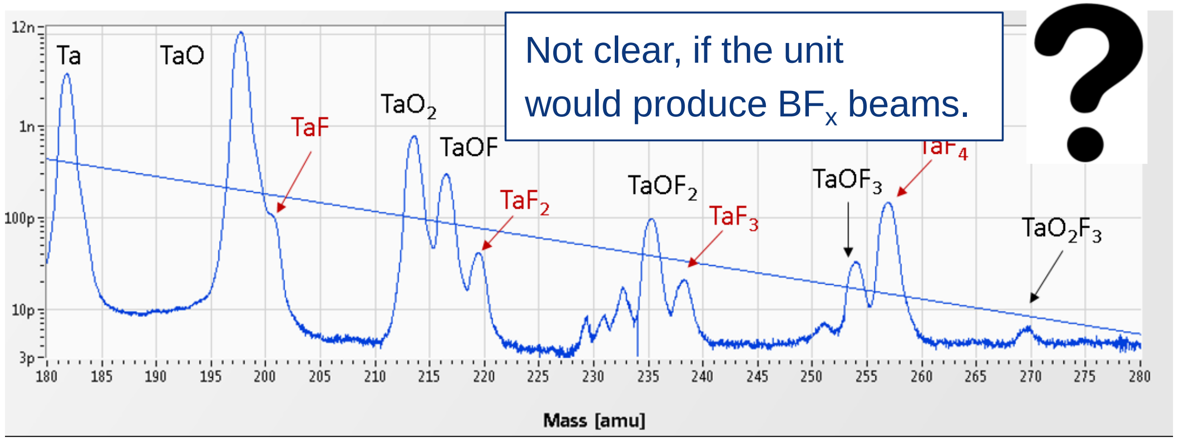
Second prototype #513

- Increased leak (1.84e-4 mbar L/s)
- Strong TaF_x and SF_x peaks
- No TaO peaks

→ Stable and intense 8BFx beams

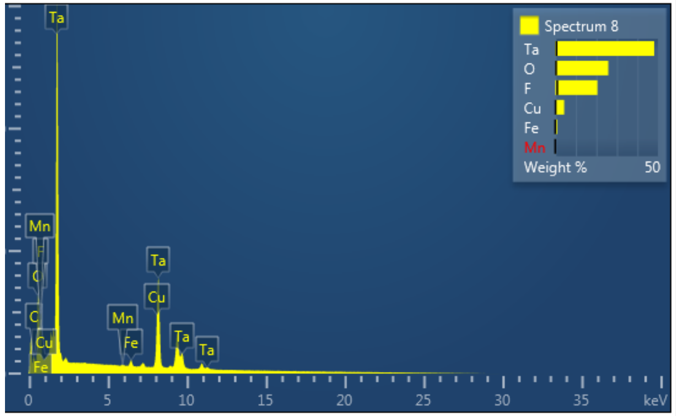
First production unit #606

Despite high injection,
low fluorination, and presence of oxygen. H_2O or air leak?



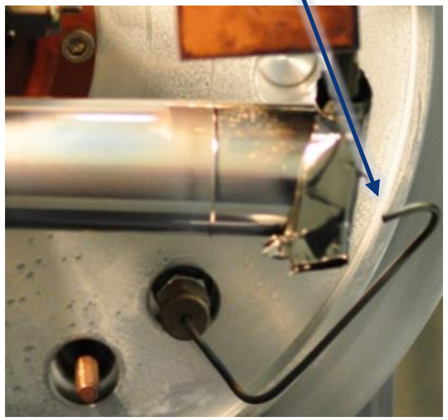
Not clear, if the unit would produce BF_x beams.

?



TaO_xF_y deposits in target

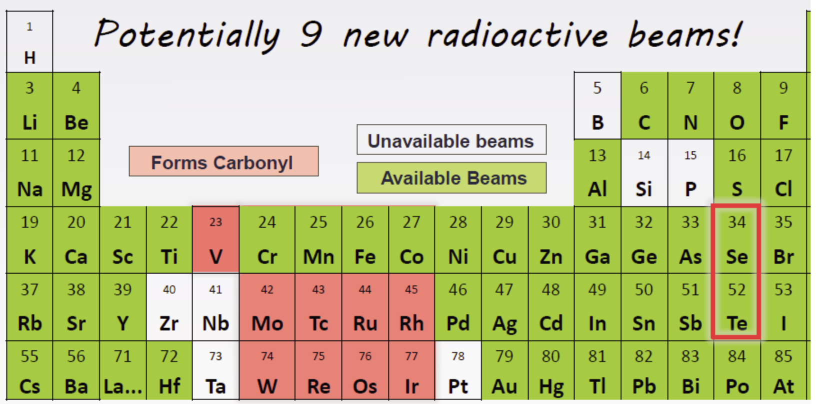
Gas line rupture



Volatile Carbonyl Compounds for New Refractory Beams at ISOLDE

J. Ballof[1,2], C. Seiffert[1], Ch. E. Düllmann[2,3,4], J. P. Ramos[1], S. Rothe[1], T. Stora[1], A. Yakushev[3,4]

Motivation

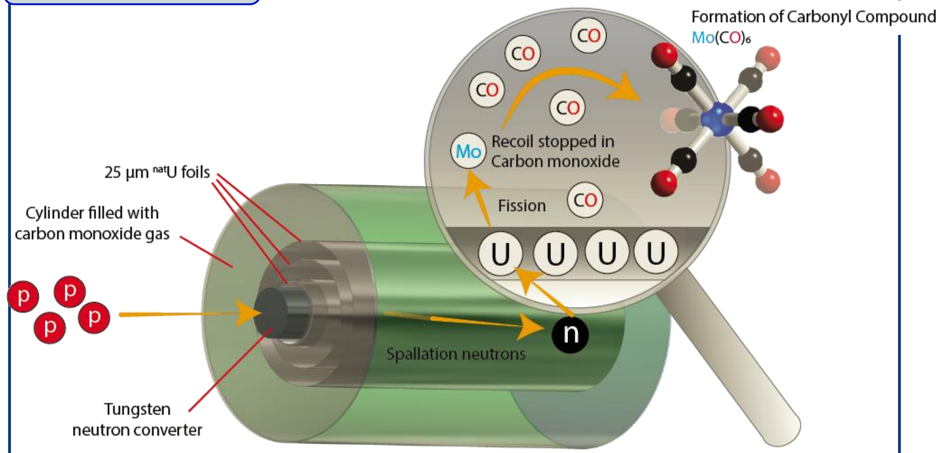

Potentially 9 new radioactive beams!

Forms Carbonyl

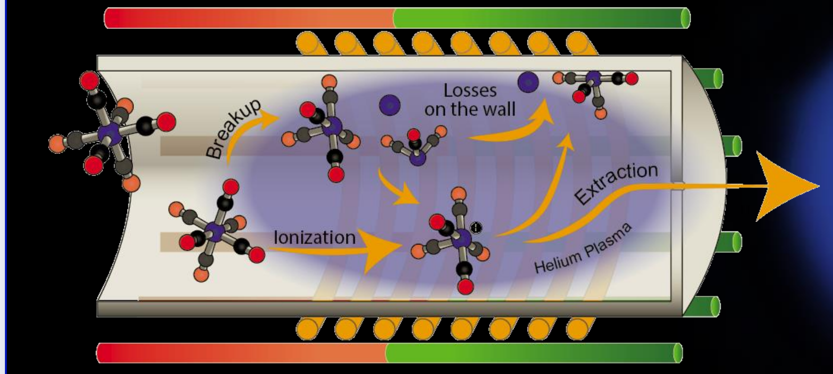
Unavailable beams

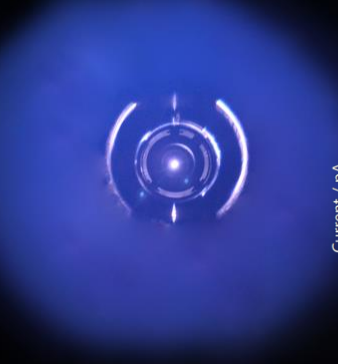
Available Beams

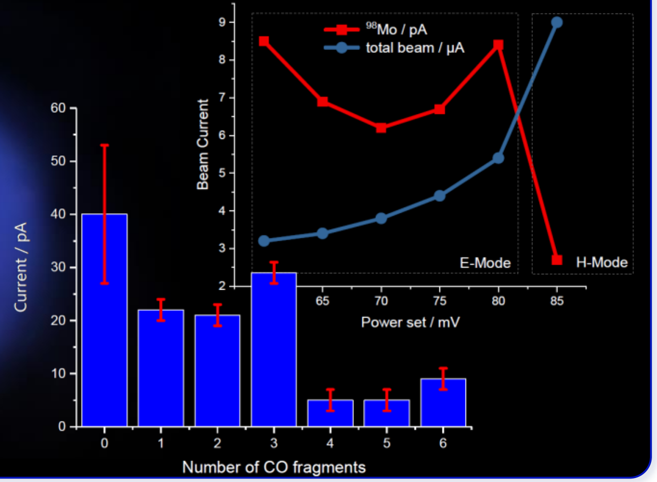
Production



Ionization







J.Ballof